A Review on Security of Fingerprint Template Using Fingerprint Mixing

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***Abstract* -Biometric recognition systems are becoming powerful means for automatic personal recognition. Nowadays, fingerprints are widely used in biometric recognition systems. In the 21 st century, having your identity stolen is no longer just a fear; it's a reality. Hence it is necessary to mitigate concerns related to data sharing and data mis use. In this method , two fingerprint from different finger are mixed to generate the new fingerprint image. Then each component is decomposed into continuous component and spiral component. Then after pre-aligning each component of fingerprint image, the continuous component of one fingerprint is combined with spiral component of other fingerprint image and vice-versa. (a) It can be used to obscure the information present in an individual fingerprint image prior to storing it in a central database.(b) mixing different fingerprint with the same fingerprint results in different identities, and (c) and is used to generate virtual identities by mixing two different fingerprint.**

***Keywords*-Biometrics, Decomposition, virtual identity, pre-alignment , spiral component.**

I. INTRODUCTION

With the increasing need for stringent security measures, biometric systems have great importance for information security systems. Hence biometric system have to satisfy high security requirements to ensure invulnerability Preserving the privacy of the stored biometric template (e.g., fingerprint image) is necessary to mitigate concerns related to data sharing and data misuse [10]. This has heightened the need to impart privacy to the stored template, i.e., to de-identify it in some way. De-identifying biometric templates is possible by transforming it into a new template using a set of application-specific transformation functions, such that the original identity cannot be easily deduced from the transformed template. A template that is transformed in this way is referred to as a cancelable template since it can be “canceled” by merely changing the transformation function [3] [17]. At the same time, the transformed template can be used during the matching stage within each application while preventing cross-application matching. Further, the transformation parameters can be changed to generate a new template if the stored template is deemed to be compromised.

Section I of this paper gives the information of necessity of security of fingerprint system , importance, security of the fingerprint image in fingerprint recognition system. Section II gives the brief literature of mixing fingerprint methods. Different algorithms and methods developed by researchers are described in this section .Section III give a concluding remark based on the literature

II. RELATED WORK

In 1947, for one dimensional (1-D) signals ,the concept of an analytic which is known as holomorphic signal was introduced to communication theory by Gabor [35]. An holographic signal consists of two parts: The real part is the base signal, and the imaginary or quadrature part is the Hilbert transform of the real part. The theory of analytic signals naturally underpins many modern concepts of signal analysis such as amplitude and frequency (AM– FM) demodulation which is used in fingerprint decomposition.

Previously the problem is how to reliably model the fingerprint minutiae? Galton [9] referred to the "minutie peculiarities due to branchings of ridges which are existing, and to the sudden interpolations of new ones" more than a century ago. And after that these features called as minutiae. Equality between optical interferograms and fingerprint patterns have been known for some time by optics researchers. In 1974 many years ago Nye and Berry [10], ridge endings in wave-fronts which are known as dislocations are uniquely associated with spiral structures in the phase representation. But fingerprint researchers do not feel to be acquainted with the connection between minutiae and phase spirals [11, 12]. Dislocations, or phase vortex spirals, have been found to be omnipresent in scalar and vector fields, and which has giving rise to an active field of research called as singular optics. In a relevant area called as 2-D phase unwrapping using the mathematical concept of residues or phase singularities, analogous results have been obtained [13-17]. Concurrently with this the optics research there have been a some key publications on oriented patterns (such as fingerprints), mainly from point of view of topology [18], image processing [19, 20], and chaotic Rayleigh-Bernard convection [21].

Mainly these works have shown that oriented patterns can be uniquely decomposed into a small number of topologically distinct discontinuities and a well defined smooth flow field. Then fingerprint research has devotated work on using the ridge orientation and ridge spacing as the basic representation. But the frequency representation fails to work properly because there is an infinite singularity at each dislocation point.Then after that in 1993 paper by Sherlock and Monro [22] introduced the idea of computing a ridge orientation map of a fingerprint and directly identifying the key directional features (known as cores and deltas) there in, but did not extend the insight to a full phase representation. Most recently Ross et al [12] have demonstrated partial fingerprint reconstruction, but complete reconstruction feels unlikely from oriented minutiae data alone. The second problem, given a suitable model (like the hologram model), is how to reliably find the parameters of model ? Mainly ,the solution of this two-dimensional demodulation problem was searched. Ideally a fingerprint model would incorporate pattern formation or morphogenesis as originally described by Turing [23] and more recently by Witkin [24]. However, it is now known that emergent features (such as minutiae) "cannot be explicitly represented in the initial and boundary conditions" of a morphogenic process [25]. In practice it is far more effective to define a model based on the final emerged properties of a pattern (in particular the exact minutiae locations). It transpires that the AM-FM fingerprint model has been attempted several times before: in 1987 Kass proposed a dominant frequency that is locally distorted by curvilinear co-ordinates [19], and more recently Chikkerur used a locally defined surface wave [7].

Real progress in fingerprint analysis has been impeded by the absence of a reliable and effective method for determining the offset, amplitude and phase. Traditionally this task (known as demodulation) has been exceedingly difficult owing to the absence of a truly isotropic and homogeneous two-dimensional analysis technique for such patterns. The most important problems of rotation and that of scale invariance have been solved in a recently proposed technique [8]. The method is known as spiral phase or vortex demodulation and effectively generalizes the Hilbert transform from 1-D to 2-D. The Helmholtz Decomposition Theorem, which is applied to 2-D phase, which means that phase can be uniquely decomposed into two parts [17]. The first part, variously known as the continuous phase, which is also called as irrotational, or also known as curl-free component is well-behaved and smoothly unwrapped. The second part, which is called as the spiral phase, also called as rotational, or also well known as divergence free component cannot be unwrapped uniquely. Conventional 2-D phase unwrapping theory can be applied to the raw phase. The use the classical residue detector of Bone [15] to find the location and polarity of all the spiral phases in the demodulated image. Positive phase spirals are represented by red, negative by blue.

For many years, researchers assume that the minutiae does not contain enough information for reconstructing the original fingerprint. However, some recent published works [1]–[4] have shown that it is possible to reconstruct a fingerprint from the minutiae. A fingerprint image reconstructed from the minutiae (hereinafter termed as a reconstructed fingerprint for simplicity) can be used to manufacture a fake finger or directly injected into a communication channel to deceive the fingerprint recognition system, which will cause serious security problems. C. Hill [1] and Ross et al. [2] pioneer the work of reconstructing a fingerprint from the minutiae. In [1], the author assumes that the minutiae template stores the coordinates of the singular points, based on which an orientation field is computed. Then, a sequence of spines passing through the minutiae points are heuristically drawn, which form a partial skeleton of the fingerprint. In [2], a set of three minutiae points (minutiae triplet) is used to estimate the orientation field defined by the triplet, while the ridges are drawn by using streamlines. The work in [2] shows promising results that it is possible to reconstruct a fingerprint from the minutiae. Cappelli et al. [3] first propose an approach that is able to reconstruct a full fingerprint image from a standard minutiae template. They estimate the orientation field by adopting an orientation field model described in [5]. According to the orientation field and a predefined ridge frequency, the ridges of the fingerprint are iteratively grown from an initial image which records the minutiae local pattern. This approach produces many obvious spurious minutiae in the reconstructed fingerprint, which can be easily detected.

The fingerprint reconstruction (from minutiae) approach proposed by Feng et al. [4] takes advantage of the amplitude and frequency modulated (AM-FM) fingerprint model [6], in which the phase image is used to determine the ridges and minutiae. The phase image contains two parts: the continuous phase and the spiral phase (which corresponds to the minutiae). In [4], the authors propose to incorporate a piecewise planar model for the continuous phase reconstruction. This model predicts the continuous phase block by block based on the gradient of the continuous phase. The fingerprint is reconstructed by combining the continuous phase and the spiral phase, which has a good matching against the original fingerprint. However, the reconstructed fingerprint does not match well when compared with different impressions of the original fingerprint. Furthermore, the piecewise planar model introduces blocking affects in the continuous phase and the reconstructed fingerprint. For fingerprint with singularity, additional artifacts may appear in the reconstructed fingerprint due to the discontinuity in the continuous phase.

The techniques for reconstructing a fingerprint from minutiae would be useful when the original fingerprint is not available or of low quality. For example, Cappelli et al. [3] point out that such fingerprint reconstruction techniques could be used for dealing with the template interoperability problem among different minutiae encoders and matchers. While Feng et al. [4] indicate that these techniques may be applied for the latent fingerprint restoration. A novel scheme is proposed to further explore to what extreme a reconstructed fingerprint can be similar to the original fingerprint. The reconstruction process is based on the AM-FM fingerprint model. Instead of using a piecewise planar model [8] to reconstruct a continuous phase with blocking effects. We propose to estimate the continuous phase from a ridge pattern which has a similar ridge flow to that of the original fingerprint. Such process is quite intuitive and will produce a continuous phase without any blocking effect. Furthermore, we can ensure that no spiral exists in the reconstructed continuous phase except at some line segments which can be easily identified. After combining the continuous phase and the spiral phase computed from the minutiae, a phase image refinement process is introduced to reduce the artifacts located at those line segments. Finally, a real-look alike fingerprint image is reconstructed according to the thinned version estimated from the refined phase image. Unlike the previous works, our reconstructed fingerprint does not contain obvious artifacts such as blocking effects or many spurious minutiae points.

Alignment is an important step in fingerprint recognition, which affects mainly the speed as well as accuracy of matching and misalignment of two fingerprints of the same finger results in false matching. Eight types of special ridges are introduced to align two fingerprint. The purpose of alignment is to estimate the translation and rotation parameters between input and template fingerprint. , so as to get the overlap of the two fingerprint for matching .Previously the ridges with maximum of sampled curvature is used as reference ridges for starting alignment. And then related special ridges are grouped in to pairs by topology get aligned by their features.The alignment parameter of translation and rotation finally come from all aligned special ridge pair.

Different alignment algorithms are based on different features extracted. Characteristic fingerprint features are generally described as global and local levels. Global features are the macro details of the whole image, such as ridge flow and pattern type, orientation field and so on. Local features are those of a point, ridge or block, which are only from a part of the fingerprint, such as minutia. The singular points (core and delta), which indicate the ridge flow and pattern types, are prominent enough to align fingerprints directly. Nilsson [26] detected the core point by complex filters applied to the orientation field in multiple resolution scales, and the translation and rotation parameters are simply computed by comparing the coordinates and orientation of the two core points. Jain [27] predefined four types of kernel curves:first is arch, second is left loop ,third is right loop and fourth is whorl, each with several subclasses respectively. These kernel curves were fitted with the image, and then used for alignment. Yager [28] proposed a two stage optimization alignment combined both global and local features. It first aligned two fingerprints by orientation field, curvature maps and ridge frequency maps, and then optimized by minutiae. The alignment using global features is fast but not robust, because the fingerprints from the same finger may be the impressions of different area of the fingertip, and some missing and spurious local features make the global features different.

Local features are always robust but need more computation in alignment. Minutiae features contain most of a fingerprint's individuality, and are the most important features for fingerprint verification system. Ratha [29] proposed the Generalized Hough Transform for the alignment. The translation as well as rotation of each pair of potentially matching minutiae need be calculated and the most likely translation and rotation parameters were chosen by the minutiae pair so-called reference minutiae. Algorithms of alignment based on minutiae always need test all possible minutiae pairs. They are accurate but computationally expensive. And many spurious minutiae are extracted from low quality images. It increases the computation, and may also result in false alignment and matching. Several the features are combined with minutiae for alignment. Jiang [30] exploited the structural information of distances between minutiae, relative differences between minutiae directions, minutiae types and ridge counts to find a likely correspondence minutiae pair. Feng [31] combined minutiae-based and texture-based descriptors of every minutia, and chose the top most similar minutiae pairs for alignment. But choosing the reference minutiae directly induces that the adjacent minutiae pairs align well but the minutiae pairs far away do not align satisfactorily. Optimization of the alignment of reference minutiae to find transformation which minimized the distance between all corresponding minutiae pairs was proposed by Ramoser [32]. Zhu [33] introduced global alignment of all corresponding minutiae pairs after selecting the reference minutiae. They made great improvement in accuracy of alignment, but did not take into account of the prominent features to reduce the computation.

Now the components of individual fingerprints are prealigned to a common coordinate system prior to the mixing step by utilizing a reference point and an alignment line. The reference point is used to center the components. The alignment line is used to find a rotation angle about the reference point. For making it vertical, this angle rotates the alignment line.The reference point used in this work is the northern most core point of extracted singularities.

The first step in finding the alignment line is to extract high curvature points from the skeleton of the fingerprint image's continuous component. Next, horizontal distances between the reference point and all high curvature points are calculated. Then, based on these distances, for selecting and clustering points near the reference point an adaptive threshold is applied. Finally, a line is fitted through the selected points to generate the alignment line. Since the continuous component of a fingerprint is a global and consistent feature of the fingerprint pattern and is not affected by breaks and discontinuities which are commonly encountered in ridge extraction, the determined reference point and alignment line are consistent and do not reveal any information about the minutia attributes which are local characteristics in the fingerprint. Then after pre-aligning two fingerprint component the continuous component of first fingerprint image is combined into spiral component of other fingerprint and vice-versa to generate virtual identity. Variations in the orientations and frequencies of ridges between fingerprint images can result in visually unrealistic mixed fingerprint images [34].This issue can be mitigated if the two fingerprints to be mixed are carefully chosen using a compatibility measure. In this paper, the compatibility between fingerprints is computed using non minutiae features, viz., orientation fields and frequency maps of fingerprint ridges. The orientation and frequency images were computed from the prealigned continuous component of a fingerprint.

III. CONCLUSION

From the above literature it has been seen that there are many methods of fingerprint decomposition , pre-alignment, each one has subjective pros and cons. The concept of "mixing fingerprints" can be utilized to generate a new identity by mixing two distinct fingerprints, de-identify a fingerprint by mixing it with another fingerprint, this can be utilized to generate a database of virtual identities from a mixed fingerprint dataset also the mixed fingerprint is dissimilar from the original fingerprints. Further work is required to enhance the performance due to mixed fingerprints by exploring alternate algorithms for prealigning, selecting and mixing the different pairs.

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